HARVARD SCHOOL OF PUBLIC HEALTH

OCCUPATIONAL HEALTH
PROGRAM

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HARVARD HEALTH SURVEY

July 13, 1982

Ms. Elizabeth Cross
Director of Personnel
Chemical Fabrics Corp.
Water Street
PO Box 476
N. Bennington, VT 05257

Dear Lisa:

Enclosed is a copy of the Health Hazard Evaluation done at ChemFab. We apologize for the delay in getting it to you; several staff people have been out of town. Please have Mr. Tilgner contact Tom Smith (617-732-1165) at his convenience to set up an appointment to discuss the report.

Sincerely yours,

Melinda Tuhus

Melinda Tuhus
Staff Assistant
Health Hazard Evaluation Program

KEY WORDS

Impotence, erectile dysfunction, polymer fume fever, fluoropolymers

II. INTRODUCTION

In December, 1980, the management of Chemical Fabrics in North Bennington, Vermont, requested a health hazard evaluation of their plant producing fluoropolymer-reinforced architectural fabric. The purpose of the study was to evaluate complaints of impotence possibly related to workplace exposures among hourly and salaried employees. The onset of reports of sexual dysfunction had been within the past 36 months. The management engineers and scientists had been unable to identify a cause of a general medical evaluation by a family practice physician of three of those making initial reports. Investigations were conducted on January 6, 1981, January 19-21, 1981, and April 22, 1981, to ascertain the extent of the problem, the exact nature of the clinical complaints, the etiology of the symptoms and to characterize the workplace environment.

III. BACKGROUND

The objective of the process is to coat fiberglass or synthetic fabric with a fluorocarbon polymer to increase the strength and durability of the fabric. The fabric is drawn through an aqueous emulsion of fluoropolymer beads and then through a vertical tower oven, which sinters or melts the polymer into the fabric. The fabric comes in two widths, 3-4 feet and 15-20 feet, and is treated by the manufacturer with an oil base sizing agent that must be burned off ("heat cleaned") prior to processing. This sizing is replaced with a silicone sizing agent that is applied in an aqueous emulsion (with or without fluoropolymer) and is sintered into the fabric.

The emulsions through which the silicone-treated fabric is drawn are aqueous dispersions of PTFE (polytetrafluoroethylene), FEP (fluorinated

ethylene- propylene), silicone, or combinations thereof. The fluoropolymer emulsion also contains ammonium perfluoro octanoate and Triton X-100 (an emulsifier and surfactant). The silicone emulsion also included toluene. The behavior of these chemicals as they intereact at high temperatures is quite complex and poorly characterized at this point. The emulsions are mixed and diluted to the required concentrations in a mixing room located off the process floor, and transported to the towers in 55 gallon drums.

During application, the emulsions are placed in a long trough at the base of the oven. The fabric is drawn through the trough and coated, and then through the oven, where it encounters successively hotter zones. The processing of a single roll can involve as many as twelve successive dips and different process temperatures. On a single pass through the oven, first the emulsion water is boiled off, then the surfactant is pyrolyzed off, and finally the polymer is sintered into the fabric. This operation is called a fuse-dip. The operator controls the thermostats on the heating zones, adjusting the gas or electric heaters to maintain proper temperature.

After the polymer processing is completed, further operations may be necessary to finish the product. Two of these operations involve high temperature and/or pressure.

The first of these involves heat-sealing the edges of the wide fabric product with a two-ply PTFE/FEP tape. This is done with a hot (370°-400°C) press as well as with a pair of hand-held heated pliers. The other finishing operation involving potential exposure is the lamination of precut one meter squares of product in a high pressure and temperature platform press. These laminates are sawed into smaller pieces and used as structural support elements in circuit boards and instrument panels.

The manufacturing processes are conducted in a large, open area approximately 130 feet wide, 300 feet long, and 20-30 feet high (Figure 1). At one end of the building there are two floors of enclosed offices, an enclosed quality control laboratory and an employee lunch area that is not enclosed. At the other end of the area are the maintenance shops, a large R & D laboratory and mixing rooms and storage areas which are accessible through two sets of doors, but which are not open to the general plant atmosphere. There are no structural barriers to air circulation except for the office and laboratory enclosures, and there is considerable air movement inside the building. To the extent that the offices and laboratories are not airtight and that there is traffic in and out of the offices, mixing of the production area air and the office air can occur.

IV. EVALUATION CRITERIA

A. Environmental

Six sources of expousre were identified and targeted for sampling and observation. These sources differ from each other in terms of magnitude, method of heat generation and type of operation (Figure 1):

Source 1: Towers F and H are electrically heated narrow fabric towers. During the time of the site visit, only Tower H was operating. This tower is adjacent to the slitting department, in which tape is cut to width and rerolled, and is also adjacent to the calender process. Any contaminant expousre generated at Source 1 would be highest for the tower operator. The contaminant may also drift into the slitting department and the calender press area, and then enter the general atmosphere of the plant.

Source 2: Towers A-D are narrow fabric, gas-heated towers. The calender press operator also assisted in this area. These men would incur highest expousre in the event of contaminant generation at Source 2, after which the contaminant would be dispersed.

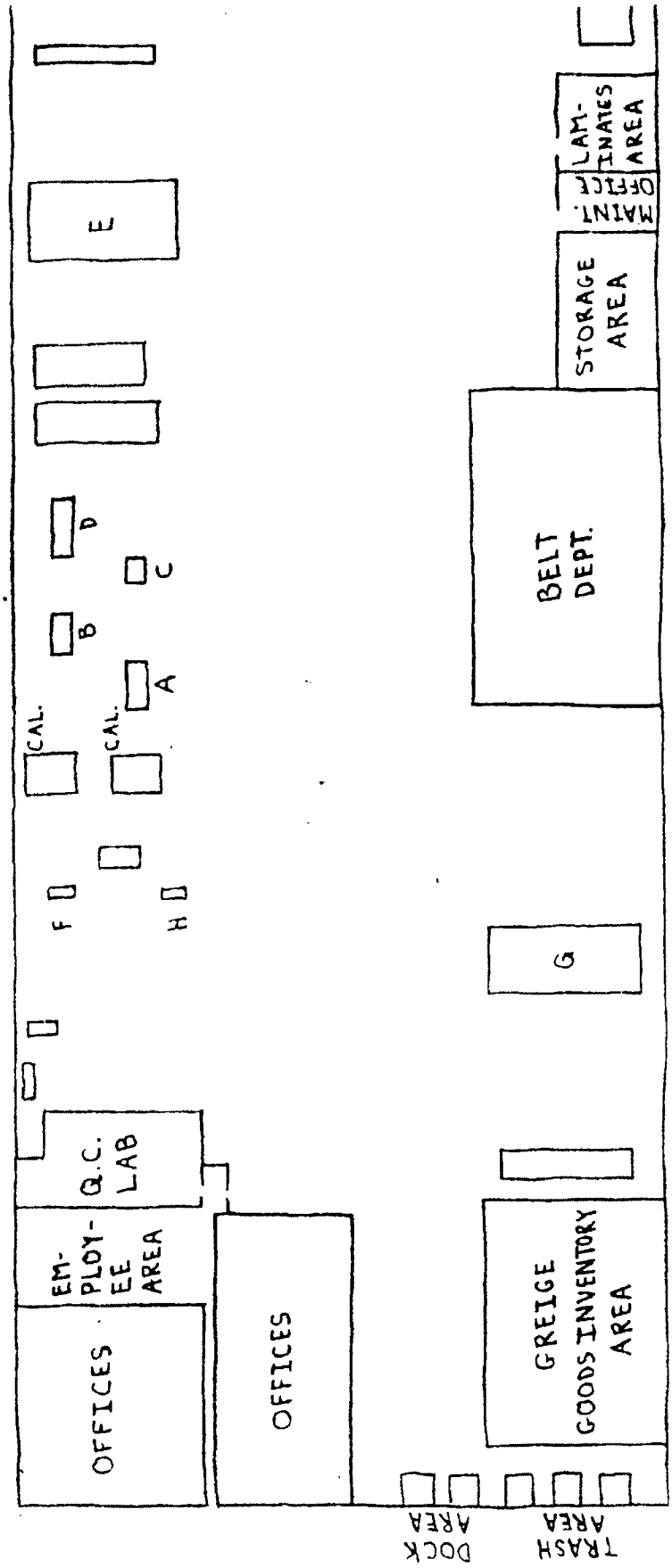
Source 3: Tower E is the older of the two wide-fabric, gas-heated towers. Exposure from this source would initially be experienced most intensely by the two tower operators, and to a lesser degree by the two workers in the adjacent rerolling area.

Source 4: Tower G is the new wide-fabric, gas-heated tower. This tower is located near the loading docks, the belting department, management offices and the employee lunch area.

Source 5: The heat sealer is in the belting department. Local exhaust ventilation was recently installed at the heat press, but the hand-held pliers have no ventilation. The exposures in this area are silicon fumes and pyrolysis products of PTFE and FEP fluoropolymers.

Source 6: Laminating occurs only every few weeks for a one-week period. The press is in an isolated area and expousres beyond the immediate area are small. Localized exposures to vaporized fluoropolymer and pyrolysis products could be significant.

Miscellaneous Sources: There are other potentially important exposures that we observed at the plant, particularly air contaminants from the cold emulsions. Volatile compounds are added to the emulsions by the manufacturers and can be smelled during liquid dilution and transfer. Exposures to propane combustion products and to various unknown chemicals during the maintenance and failure of the abator are also possible.



CHEMICAL FABRICS CORP.
N. BENNINGTON, VT.
Fire Safety Plan
Scale
1" = 30'

FIGURE 1

B. MEDICAL/TOXICOLOGICAL

Male erectile dysfunction induced by exposure to workplace toxins has not been reported in the absence of bladder dysfunction. Kreiss et al., reported a bladder neuropathy due to dimethylaminopropionitrile (DMAPN) which caused severe bladder symptoms, most of which were reversible after removal from exposure to the catalyst (1). Some of the men affected by the bladder neurotoxin, which caused bladder sensorimotor neuropathy, also complained of erectile dysfunction which did not necessarily improve when exposure ceased and bladder function improved (2). Siroky et al., performed Sacral Signal Tracing on a patient with erectile dysfunction after perchlorethylene exposure, but this patient also complained of urinary retention, and had a toxic peripheral neuropathy (3).

Proper sexual functioning depends on a sexually mature state (psychological), effective vasocongestive action (erection), adequate androgenic hormones, and ejaculation. Erection and ejaculation are complicated reflex responses involving both divisions of the autonomic nervous system (4). In man, efferent neural impulses for erection are thought to arise from parasympathetic fibers in sacral cord roots S_2, S_3 and S_4 (Figure 4). These are the same spinal roots that provide efferent (parasympathetic) supply to the detrusor muscle of the urinary bladder and to the distal colon and rectum (5). Thus, the pelvic nerves from the sacral cord segments conduct the parasympathetic impulses for erection, urination, and defecation. Men with partial spinal cord injuries but intact pelvic nerves frequently have a dissociation of bladder, bowel, and erectile function - e.g., normal bladder and bowels, but erectile dysfunction. Similarly, damage to nerves in the pelvis may alter one of these physiologic functions without affecting the others.

Hence, although the neural pathways may be similar, they are not identical. In increasing order of vulnerability are bowel, bladder, then erection (6).

Research on the role of higher centers and other spinal cord segments reveal that an outflow from the thoracolumbar cord acts synergistically with the spinal parasympathetic outflow to mediate penile erections (5,6). The sacral erection center receives reflex-arc input from both local stimuli (via the pudendal nerves) and from psychic (mental) stimuli originating in the higher centers of the CNS. The thoraco-lumbar center receives reflex-arc input from the higher centers of the CNS but not directly from reflexogenic stimuli. Autonomic nerves from the (sympathetic) and vasodilator (cholinergic) fibers (4). The failure of direct electrical stimulation of these nerves (in animals) to produce penile erection may be attributed to simultaneous stimulation of the antagonistic fibers. Presumably an erection-mediating (vasodilator) component is selectively activated by erotic stimuli. In normal males it is difficult to assess the relative contributions of the thoracolumbar (sympathetic) and sacral centers (parasympathetics) in producing erections, but it is clear that in cases of complete impotence the outflow from both centers must be compromised.

As noted above, the higher centers, or cerebral contribution to erection, is also important. The cerebral localization of penile erections in humans is not clear. Indeed, little is known about the physiologic mechanisms and anatomic pathways that mediate cerebral inhibition of erection. This information would be essential in understanding the psychological causes of erectile dysfunction (7).

Hormonal factors also contribute to normal erections. A sufficient amount of circulating androgen is required to permit adequate male func-

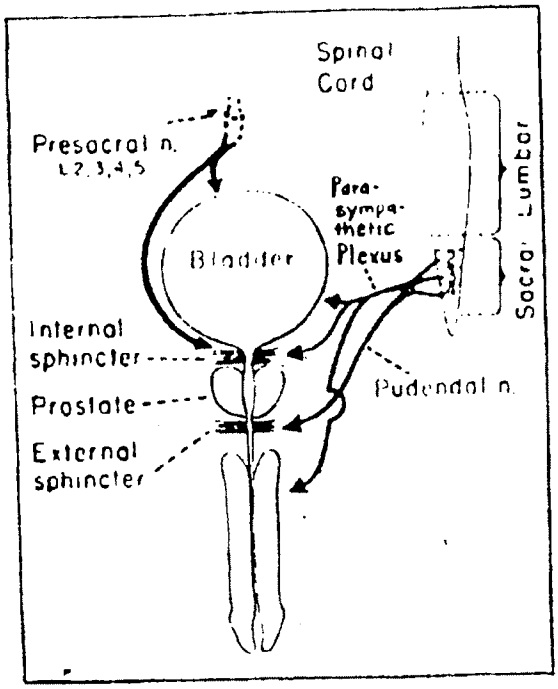
tion. However, normal adult men show a wide range in plasma testosterone concentrations and the mechanism by which androgens influence male sexual function in unclear.

Circulating testosterone levels are not stable and are characterized by fluctuations superimposed on a circadian rhythm with peak testosterone concentrations occurring in early morning (8). There is also recent evidence that psychological/psychosocial stress may depress plasma testosterone (8,9). However, there is as yet no evidence for a relation beetween circulating androgen levels and differences in sexual behavior (10).

The last essential factor for normal erections is normal hemodynamics. The actual transformation of the penis from a flaccid to an erect state is a vascular phenomenon. Blood reaches the penis via terminal branches of the right and left pudental arteries. These arteries carry blood to the "erectile tissues" of the penis, the corpora cavenosa which lie side by side on the dorsal aspect of the penis. The corpus spongiosa surrounds the urethra. During erection, these vascular spaces are transformed into large cavities distended with blood at high pressures because the rate of arterial inflow is temporarily greater than venous outflow, thus causing an increase in penile volume (4). A steady-state is reached, where the rates of inflow and outflow are equal and the penis will no longer increase in size but remains rigid. Detumescence results from vasoconstriction of the penile arteries with subsequent decrease of arterial blood flow, decrease in pressure, and release of compressed veins (5).

There are a number of organic causes of erectile dysfunction (Table 1). Broadly characterized, these include: systemic disease with diabetes mellitus being the most common, but also alcoholism (via 2° hypogonadism, not

Figure 2 - Schematic anatomy of the bladder and penis.



cirrhosis (11)), hypopituitarism, etc.; local disorders such as congenital abnormalities and inflammatory lesions; vascular disease such as spinal cord lesions or toxic neuropathy, drugs such as antihypertensives; and surgical procedures such as prostatectomy. Endocrinopathies such as hyperprolactinemia and hyperthyroidism are also well-documented causes.

DMAPN is unique among neurotoxins in that it produced mainly bladder dysfunction, possibly by a urine-concentrating effect and in a minority of cases, male sexual dysfunction. To produce erectile dysfunction in the absence of bladder dysfunction would imply an even more specific, purely autonomic toxin, which affected erectile function but not bladder or bowel function (4,5,6,12,13).

V. METHODS

A. ENVIRONMENTAL

1. Sampling

Six types of sampling were conducted during the three-day exposure evaluation. Throughout the sampling, pump flow rates were periodically checked for accuracy. Observations of individual work practices were made and manufacturing process changes were noted. Specific sample media are listed in Appendix A.

a. Respirable Mass

Membrane filters were pre-loaded by Millipore into three-piece cassettes. The cassettes were placed into 10 mm nylon cyclones and attached via tygon tubing to personal sampling pumps calibrated at 1.7 liters per minute. The cassettes were capped and frozen until analysis.

b. Total Particulate

Total particulate samples were collected on membrane filters in closed face cassettes, through which air was drawn at 1.7 liters per minute. The used filters were frozen until analysis.

c. Total Particulate Sampling (High Volume)

A high volume sampler was used to collect the total particulate on glass fiber filters. The flow rate was 40 cubic feet per minute. Sampling was done for approximately 8-hour periods coinciding with the 8-hour work shifts.

Two sets of hi-vol filters were used. One set was taken during the evaluation periiod of January 19-21. The hi-vol sampler was raised approximately twenty feet above floor level at a site directly across from the Belt Department, on the opposite side of the storage racks. This site was used for all samples.

The second set of samples collected in March, 1981, were pre-weighed, then reweighed to measure their total weight gain. Used filters were wrapped in foil and frozen until analysis.

d. Organic Vapors

Area samples were collected on silica gel and charcoal tubes using low flow pumps (100 cubic centimeters per minute). On the first sampling day, samples were collected for 1-4 hours alternately using silica gel and charcoal tubes at each location. On the second and third days of sampling, silica gel and charcoal tubes samples were collected in parallel. All used tubes were sealed and frozen until analysis.

e. Total Particulate and Organic Vapors

TABLE 1 - ORGANIC CONTRIBUTANTS TO ERECTILE DYSFUNCTION

A. Frequently relevant factors
- Aging or idiopathic
- Alcoholism: associated with cirrhosis but pathogenesis unclear
- Diabetic peripheral autonomic neuropathy
- Diabetes: uncontrolled metabolic state
- Drugs used for therapy:
  - Guanethidine, reserpine, alpha methyldopa
  - Spironolactone
  - Anticholinergic agents
  - Estrogen
  - Methadone
- Drugs commonly abused:
  - Alcohol
  - Heroin, methadone, morphine
  - Cocaine, amphetamine, barbiturate
- Organ system failure: cardiac, respiratory, renal
- Surgical complication: perineal prostatectomy, aortofemoral bypass, sympathectomy
- Trauma: spinal cord transection
- Vascular disease: of terminal aorta and iliac arteries

B. Less common factors
- Congenital: diphallus, absent phallus, hypospadias, spina bifida, Klinefelter's syndrome
- Endocrinologic: acromegaly, Addison's disease, adrenal neoplasias, chromophobe adenoma, hypogonadism, primary and secondary types, infantilism, myxedema, hyperthyroidism, ↑ prolactin
- Infectious: ? prostatitis
- Neurologic: multiple sclerosis, spinal cord tumors, amyotrophic lateral sclerosis, peripheral neuropathies, general paresis, tabes dorsalis, temporal lobe lesions, pernicious anemia, nutritional deficiencies
- Pharmacologic: phenothiazines, butyrophenones, thiothixenes
  - Antidepressants: tricyclics and monoamine oxidase inhibitors
- Toxicologic: lead and herbicide
- Traumatic: castration
  - Pelvic fracture, penile trauma
  - Ruptured intervertebral disc
- Urologic: Peyronie's disease, hydrocele, varicocele, phimosis
  - Priapism: idiopathic or associated with sickle-cell anemia or leukemia
  - Elephantiasis

Area samples were taken using large charcoal tubes in line with cellulose membrane filters at a flow rate of 760 cubic centimeters per minute. The filters were placed in front of the charcoal tubes in order to remove any particulates that could have collected on the charcoal. The tubes and filters were capped after use and frozen.

2. Analytical

a. Sample Preparation

The personal filters were cut in two. Because the health complaint of sexual dysfunction was systemic and possibly neurologically based, lipid soluble compounds which would have affinity for nervous tissue wereexamined by extracting the filters in toluene. To one half filter, 10 ml of toluene was added and the samples were ultrasonicated for 30 minutes. Four ml of the solution was pipetted into a vial and then evaporated to dryness. The sample was then dissolved in 2 ml of methanol spiled with .437 mg benzene per liter added as an internal standard and separated by liquid chromotography.

Discs of 37 mm diameter were cut from the high volume filters. These were then treated in the same manner as the personal sample halves.

Material which had condensed in the precombustion ductwork of the combuster of the new wide tower was collected as possibly representative of some of the air contaminants. This black material was dissolved in toluene. Aliquots were deposited on filters, which were treated as the personal samples were.

To prepare solutions of the raw materials used in the process, 0.4 ml of material was added to 8 ml of methanol containing 0.5 mg benzene per ml methanol. This suspension was extracted ultrasonically for 10 minutes. To

remove those materials which would be retained on the liquid chromography column, the mixture was then passed through a C_{18} SepPak from Waters Associates. The eluting solutions were then chromatographed.

b. Gas Chromatography

First, an SE 30 Hiplate column was used to attempt separation of air sample components. A flame ionization detector was used, and the chromatographs were run both isothermally at 250°C and with temperature programming starting at 56°C and rising at 10° per minute to 325°C, where the temperature was held for ten minutes. Samples from the high volume filters extracted in carbon disulfide, DMSO, and diethyl ether were injected.

In addition, two sets of filters with charcoal tubes were sent to MetPath Environmental Laboratory for gas chromatography mass spectrometry analysis. One was an area sample from the heat seal press and the other an area sample from Tower C. Both the charcoal and the filter were desorbed with carbon disulfide and the resulting solutions were injected directly into a gas chromatograph. A flame ionization detector and a mass spectrometer were used with a 10% AT-100 column. A mass spectometer detector was also used with a Chromosorb 102 and a 3% SP-2250 DB column. All columns were 6 ft x 2 mm ID, and the temperature program increased at 10° per minute to 220°C, except for the 3% SP-2250 DB column, which reached 260°C.

c. Liquid Chromatography

All samples and material were chromatographed on a Waters Associates high performance liquid chromatograph. The separation was carried out on a _Bondpak C_{18} column, 3.9 mm ID x 30 cm, 10 um particle size. The gradient was program 2, going from 75% methanol/25% water to 100% methanol. Initially, 50 ul injections were made, but these were soon increased to 200 ul,

which were used for most analyses.

Samples were automatically injected by the 710B WISP, pumped by the model 6000 and model 45 solvent delivery systems controlled by the Model 660 Solvent Programmer. The eluting compounds were monitored with a Model 440 Absorbance detector at 254 mm and 280 mm with the use of the model 730 data module, which printed the chromatograms, determined retention times, integrated the areas under the peaks, and calculated the amount to material present using the benzene internal standard and assuming a response factor of 0.1010 for all compounds. All samples were run in duplicate and the concentration results were averaged.

B. MEDICAL

During the initial walk-through site visit, three of the affected men were interviewed. This initial interview served as a guide to the questionnaire (Appendix B) and survey conducted three weeks later. At this time, all available employees were asked to volunteer to be interviewed concerning job description, smoking and hygiene habits, general medical history, respiratory, neurologic, and genito-urinary symptoms. They completed the American Thoracic Society (ATS) Respiratory Questionnaire (14), as well as the Profile of Mood States (15). They were also interviewed by a physician regarding specific medical and sexual histories, alcohol and drug use, and job-exposure description. Each step of the medical evaluation with the exception of the medical interview was performed with the examiner "blinded" as to which individual was symptomatic or not.

Medical examination was performed on all volunteering subjects. This included vital signs, vascular and general neurological exam. Males were also

examined for sensation to the penis and saddle regions, testicular size, and Bulbocavernosus Reflex. The Bulbocavernosus Reflex is a segmental polysynaptic reflex with cross- over in the sacral spinal cord and is tested by compression of the glans penis, grading the reflex contraction of the external sphincter ani from 0 to 2+ (16), where 0 is absent, 1+ is decreased, and 2+ is normal.

Laboratory investigation included complete blood count, differential white blood cell count, erythrocyte sedimentation rate, and serum levels of BUN, creatinine, glucose, SGOT, LDH, SGPT, alkaline phosphatase, uric acid, bilirubin, globulin, albumin, calcium, phosphorus, iron, testosterone, and prolactin. Urine was collected for the 16 hours away from work for creatinine and drug analysis, as well as fluoride analysis (total and organic). Urine and serum samples were obtained for spectrographic and chromatographic "finger-printing" analysis.

A follow-up survey (Appendix C) was conducted in April, 1981, after preliminary results of the initial health survey served to focus attention on several specific areas: the exact nature of exposures in the plant, prior jobs (in and out of this plant), details of the sexual history, polymer fume fever history, duration of sexual symptoms and fume fever symptoms in relation to exposure. The follow-up survey focused on the 10 male subjects reporting sexual dysfunction on the first survey plus 18 other men who were symptom-free but similar in age and duration of work.

A case of male erectile dysfunction was defined as difficulty in getting an erection either during sexual intercourse or masturbation except on rare occasions. The time course of symptoms of erectile dysfunction and its persistence or resolution were documented during the follow-up survey (April).

All male employees who worked at the plant were assumed to be at risk except those with known erectile dysfunction prior to exposure.

The medical evaluation revealed that a number of men had experienced episodes of polymer fume fever. A case of polymer fume fever was defined as shaking chills, myalgias, shortness of breath or chest tightness and malaise with or without measured increase in temperature occurring near the end of or after a work shift, and complete recovery within 24 hours (17,18). "Incomplete" or "partial" polymer fume fever is defined as a combination of myalgias or headache or chest tightness, throat irritation and/or cough, but no shaking chills or measured increase in body temperature and quickly aborted by 10-30 minutes of fresh air.

VI. RESULTS

A. ENVIRONMENTAL

1. Observations during the Environmental Survey

*Source*1: The nature of the electric heating was such that the radiator thermostat was set 260 ° higher than the desired fabric temperature. It is possible that the air-flow inside the tower is quite turbulent due to convection and ventiltion, and airborne substances generated by the sintering fluoropolymer at 370° could come in contact with the 650° C radiators. Since the toxicity of fluoropolymer pyrolysis products has been reported to increase at higher temperatures, this turbulence could affect the nature of the contaminant generated at Source 1.

Over the course of the three days that we spent in the plant, Tower H was the only tower operating in Source 1 that was observed doing dry-fuse and fuse drip runs. At no time was visible contaminant generation noticed, and discussions with the operator, the only female operator in the plant, indicated no

unusual process conditions.

Source 2: The four gas heated narrow fabric towers (A-D) were all operating during the observation period. No visible contaminant generation was observed here, although the marks on the ceiling near the towers indicate that emissions may have occurred in the past.

Source 3: No complaints were received from either of the two operators of the old wide tower (E). We did not observe any smoke generation during either of our tours when this tower was operating.

Source 4: The new wide fabric tower (Tower G) was observed to produce significant amounts of visible emission. Five minutes after start-up, the center portion of the tower, between the ascending and descending fabric, began to fill up with smoke near the Local Exhaust Ventilation (LEV) takeoff. In a few minutes the entire center portion would be quite smoky, and the contaminant would begin to flow out from beneath the baffle that surrounded the tower and hung from the ceiling to within 15 feet of the floor. The smoky emissions were hot, and flowed up to the ceiling by convection. Within 15-20 minutes, a distinctly visible white haze was apparent at the end of the plant near Tower G. Workers in the lunch area, the loading docks, the belting department, and management offices were exposed to these contaminants. The emissions from Tower G accumulated near the ceiling so the workers who spend time near the ceiling, e.g., maintenance workers doing work on the ovens, would have the highest exposure. No runs with silicon were made during the time of the survey, but it was reported that smoke generation during these runs is worse than that observed.

It was observed that the plant atmosphere cleared quickly when the loading dock doors were opened, allowing escape of the warm contaminated air through the roof vent. It also appeared that the smoke generation at the tower was reduced due to more efficient LEV operation with the doors open. An undesirable

side effect was that the temperature inside the plant was noticeably lower.

Source 5: The heat sealing procedure was observed twice during the survey. The highest exposure occurred when the hand-held pliers were used to melt the PTFE/FEP onto the product. This operation is unventilated, and visible fumes drift upward into the breathing zones of men performing the operation and those nearby. Most of the heat-sealing, however, is done in a three-foot long horizontal press, which was unventilated until immediately after the January 6, 1981 visit to the plant, when a small hood was installed over the press. This hood is subject to the mitigating effect of insufficient make-up air in connection with the tower LEV. Although it is not 100% effective in eliminating exposure, exposure has been reduced.

The men in the belting department were aware of the irritating effects of the smoke. They also reported that the fumes generated when fresh silicone paper was used to cover the heated elements of the press were especially irritating.

Source 6: The laminating press was not observed by industrial hygiene personnel while it was running. It is quite possible that contaminants could be produced during this process since it uses large amounts of heat and pressure, the working surface is at breathing level, and the press area is unventilated.

There are several process parameters which vary from one run to the next, and they could affect the amount and the nature of the contaminants generated from Sources 1-4:

- Use of emulsion: in general, contaminant generation rate will increase as the amount of pyrolyzable material on the fabric increases. Any run in which an emulsion is used will generate more smoke than a dry (no emulsion) run. The important exception to this is the "heat clean," in which large amounts of oil

base starch are pyrolized off.

- Process temperature: more contaminant will be generated at higher specific gravities because of increased amount of solids on the fabric.

- Silicone: more contaminant is reportedly generated in a dip through an emulsion containing silicone.

- Fabric fiber size: more contaminant is expected to be generated with small fiber sizes and tighter weaves due to increased surface area available for adsorption of emulsion.

- Type of fluoropolymer: product information from Vermont shows that FEP decomposes much more rapidly than PTFE at elevated temperatures. Increased FEP concentration in the emulsion will increase the contaminant generation rate.

- Sequence of dips: it was reported that the earlier dips on a roll of fabric tended to be more smoky than the late dips.

- Method of tower heating: any differential effect is not known, although the electrically heated towers need to be thermostated much higher than the gas heated towers to maintain the same process temperature as the fabric.

It is known that many of these variables change from run to run, but it would be impossible to suggest what the overall effect would be. It is possible, however, to predict that some emulsion treatments, e.g., a high specific gravity silicone/fluoropolymer dip run at high temperature, could be expected to generate more contaminant than other treatments.

On a more general level, there was a lack of any precautions against the ingestion of chemicals. Much splashing and skin contact occurred during liquid transfer, and employees ate, drank, and smoked at their work stations.

It was also observed that the potential exists for hazardous exposure during abator maintenance. With some types of emulsion runs, the catalyst must be removed and cleaned weekly. Cleaning, which is accomplished by slowing off the silica that forms on the catalyst with compressed air in an unventilated area, is a very dusty operation. The white silica that clogs the catalyst was reported to be an oxidation product of the silicone compounds. Further discussions with several plant personnel provided different reports of how much respiratory protection is used during catalyst cleaning. As a result, exposure to silica dust may occur to a greater extent than work practices are designed to permit.

2. Analytical

a. Gas Chromatography

Only the solvent peaks were detected in the gas chromatography on the SE 30 Hiplate column. MetPath Environmental Labs reported that five different components were separated from the filter samples, but only toluene was identified. Six components were detected in the charcoal tube samples, but again only toluene was identified. Reportedly the concentration of the other components was too low for satisfactory mass spectra.

b. Liquid Chromatography

Liquid chromatography was used to separate the components of the air samples as well as the raw materials. The methanol extracts of air samples were separated into between 11 and 24 different components; the raw materials were separated into between 13 and 21 chromatographic peaks (Table 2); and the chromatogram of the black condensate had 22 peaks. A typical chromatogram is shown in Figure 3.

Almost all the chromatographic peaks found in the exposure samples match the retention times of the components of the raw materials. The major exception was the material which eluted at 2.08 minutes; this material was found in about two-thirds of the samples, often as a large peak. The only other exception

TABLE 2 - AREAS OF ALL PEAKS OF METHANOL EXTRACTS OF RAW MATERIALS

On the following table the principal results of the liquid chromatography of the toluene extract of the raw materials are given. The retention times of all peaks are listed in the left column. The entries in the table are proportional to the absorbance of the compounds at 254 nm. For any given compound, a large number represents a greater concentration of that compound. However, one cannot use the absorbance to compare the relative concentrations of two different compounds, as these will have different absorptivity coefficients at 254 nm.

TABLE 2 - AREAS OF ALL PEAKS OF METHANOL EXTRACTS OF RAW MATERIALS

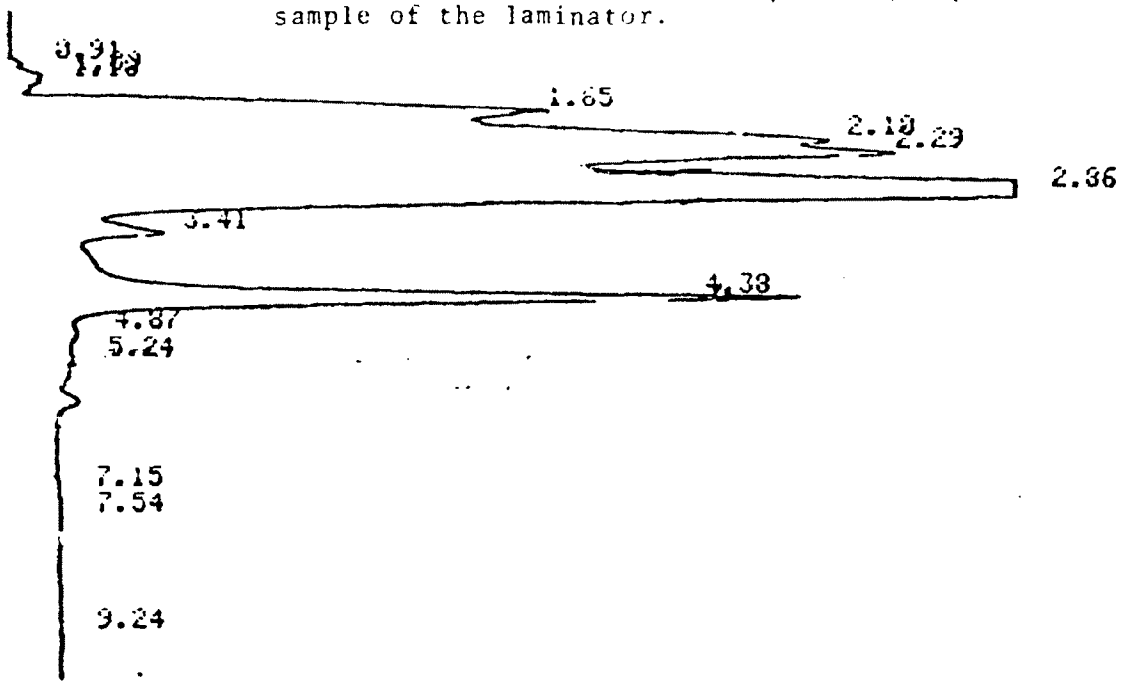
	M A T E R I A L S				
Retention Times	TE 3439	TE 3313	TE 3429	TE 9503	Silane ET 4327
.55		8			
.62	22	19	2	59	40
.82					407
1.16					
1.29		1,446	964		4,664
1.36	1,145	317		1,797	
1.48				2,925	
1.56	5,940	4,667	2,546	1,886	
1.60	3,164	3,943			
1.68	1,290		3,607	4,368	16,411
1.85	973	2,435	1,384	2,692	3,445
2.28	21,853	22,318	14,076	18,371	18,722
2.66					
2.85	100,966	103,004	88,192	136,935	129,600
3.25					
3.28					
3.45				5,504	6,090
3.70	17,951	17,156	1,640	12,609	12,172
3.90	292				
4.02					
4.35	477,728	482,992	436,708	476,750	310,852
4.64					
4.82					
5.10	507	960	172	411	187
5.45	574	1,095		1,031	237
5.60					244
5.76					
5.95	9,856	11,900	10,052	10,427	12,374
6.84	267	560	454	374	
7.25	389	1,250	231	381	956
7.60	58				
7.90					
8.06					463
8.30					
8.50					
8.76		179			
8.90					
9.10					
9.25					
9.70					

Chromatographic conditions: column: μ Bondapak C_{18}
solvent: initial: 75% methanol:25% water
final: 100% methanol
gradient: program 2
flow rate: 2 ml/min
detector: UV: 254 nm

Table 2 continued . . .

Retention Times	M A T E R I A L S ET 3280	ET 4327	Tritan-X-100	Thamol T 721	BW 3727
.55		35			24
.62					
.82					
1.16		18,620			
1.29				1,726	
1.36		6,344			
1.48		6,700			
1.56	165,863		194,920	30,883	1,765,000
1.60					
1.68		24,760	4,561	67,818	
1.85			5,581		
2.28	22,120	21,345	66,870	187,400	
2.66					175,000
2.85		129,730	273,640	158,920	
3.25					2,290
3.28			1,281,800		
3.45	1,651,560	118,930			
3.70		3,970		58,690	3,950
3.90		6,868			
4.02	8,143		11,074		6,560
4.35	15,200	390,770	12,340		1,900
4.64	6,408		9,650	3,433,000	
4.82	80,000				146
5.10		366	9,832	13,750	162
5.45	35	260		26,760	
5.60					
5.76					179
5.95	62,372	21,740	69,770	247,000	
6.84	267,700	60,920	250,161	1,930	
7.25				20,000	
7.60	86,760	17,625	83,086		
7.90	20,331	4,070	23,116		
8.06				380	
8.30	59,400	9,360	61,590		
8.50	22,470	3,650	25,412	2,800	
8.76					
8.90	60,360	8,020	71,180		
9.10	32,900		15,808		
9.25	16,370				
9.70	35,830	2,580	47,713		

sample of the laminator.



360

SAMPLE POSITION 16 AUTO MODE WISP REPORT

INJECTION VOLUME 0200
NUMBER OF INJECTIONS 2 INJECTIONS REMAINING 1
RUN TIME 00:10 EQUILIBRATION DELAY 00:05
NON-DEFAULT SYS MSG'S: 6500-0030 PSI
WISP CODES GENERATED:

JUN. 18, 1981 03:10:35 CHART 1.00 CM/MIN
RUN #97 CALC #0
COLUMN SOLVENT OPR ID: 5

EXTERNAL STANDARD QUANTITATION

PEAK#	AMOUNT	RT	EXP RT	AREA	RF
	0.00198	0.91		19623 F	0.101000E-3
	0.00972	1.09		96254 F	0.101000E-3
	0.00942	1.18		93299 F	0.101000E-3
	0.42036	1.65		4162015 F	0.101000E-3
	0.70396	2.10		6970010 F	0.101000E-3
	0.62910	2.29		6228809 F	0.101000E-3
1	1.51469	2.86		14997020 F	0.101000E-3
	0.07904	3.41		782608 F	0.101000E-3
	0.50544	4.38		5004457 F	0.101000E-3
	0.00693	4.87		68703 L	0.101000E-3
	0.00336	5.24		33346 F	0.101000E-3
	0.00770	5.89		76251 L	0.101000E-3
	0.00105	7.15		10415 F	0.101000E-3
	0.00273	7.54		27080 L	0.101000E-3
TOTAL	3.89554				

was a very small peak with retention time of 6.5 minutes, which was found in one personal sample from the slitters, one from the calender operator, one area had a personal sample from Tower G, and an area sample from the heat seal press.

Qualitatively the chromatograms of the air samples are remarkably similar to each other. This similarity is probably due to the fact that the air mixes and flows throughout the building. Only ten rooms, offices and labs, are enclosed. During the walk-through of the production facility one could see that the ventilation system was not capturing all the emissions. This mixing and free flow of air probably makes exposure qualitatively homogeneous throughout the plant.

Table 3 lists the relative areas under the most important peaks for the various job categories. To do a semi-quantitative comparison, a cut-off value was chosen for each peak above which value exposure was deemed to be high compared with most samples. From Table 4 one can see which job categories or areas of the plant have relatively high exposure to the compounds represented by the retention times given. The cutoff values used for each peak are given at the bottom of the page. At least half of the samples in each category had to be above the cutoff level of a given peak in order for exposure to be designated as high (H).

The major area of variability which can be seen from inspection of the chromatograms is the area of the peaks with retention times 1.68, 2.08, and 2.28. For instance, the twelve personal samples taken from near the towers (Towers E, G, B and the gas Towers) were quite similar to each other, and the eight areas samples from all the towers were quite similar, but the area samples had much smaller peaks at 1.68, 2.08, and 2.28 than the personal samples. By contrast, the tower area samples had a large peak with retention time 4.35, which was larger than the personal samples. Samples taken from near the heat seal press have larger peaks with retention times of 7.2 and 7.7 than do any of

TABLE 3 - AREAS OF MAJOR PEAKS FOR JOB CATEGORIES AND AREA SAMPLES

On the following table the principal results of the liquid chromatography of the area and personal samples are given. The retention times of some peaks are listed in the left column. The entries in the table are proportional to the absorbance of the compound at 254 nm. For any given compound, a large number represents a greater concentration of that compound. However, one cannot use the absorbance to compare the relative concentrations of two different compounds, as these will have different absorptivity coefficients at 254 nm. To make the results comparable, all sample values were corrected to eight-hour shifts with flow rates of 1.7 lpm. The sample numbers are given across the top of the table. Those preceded by a "P" are personal samples, that is the filters were worn by the worker and represent the actual exposure of the worker; those preceded by an "A" are area samples, and were left at one location.

TABLE 3 - AREAS OF MAJOR PEAKS FOR JOB CATEGORIES AND AREA SAMPLES

	CUTTER FILTER SAMPLES		
Retention Times / sample no. / date	P 304* 1 - 19	P 375 1 - 20	P 396 1 - 21
1.68	6,495	196,710	84,070
2.08	3,658		
2.18	8,993		
2.29	-	473,982	263,002
4.35	40,000	61,280	58,100
5.80		10,200	1,760
7.10		110	220
7.85		80	60
8.85		75	
9.35			
9.60		8	

*50 µl injection volume

Chromatographic conditions:

Column: µ Bondapak C_{18}

Solvent: Initial: 75% methanol: 25% water
Final: 100% methanol
Gradient: Program 2

Flow rate: 2 ml/min

Detector: UV: 254 nm.

TABLE 3 continued . . .

CALENDER OPERATOR

FILTER SAMPLES

Retention Times	P 315 1 - 19	P 367 1 - 20	P 392 1 - 21
1.68	29,805	96,558	166,378
2.08	17,596	120,355	326,341
2.29		87,010	137,861
4.35	65,880	72,300	49,390
5.80	3,720	8,510	1,250
7.10	200	32	140
7.85	36	17	
8.85	140	160	204
9.35			
9.60		130	

TABLE 3 continued . . .

LAMINATOR (at night)

FILTER SAMPLES

Retention Times	P 307* 1 - 19	P 360 1 - 20	A 311 1 - 19	A 353 1 - 20
1.68	1,238	87,472	490,781	709.956
2.08		140,280	468,868	772,514
2.18	2,649		446,006	570,676
2.29		123,845	235,430	252,060
4.35	70,000	101,130	7,570	12,740
5.80		2,760	260	
7.10		460	425	
7.85				
8.85				
9.35				
9.60				

TABLE 3 continued . . .

ELECTRIC OVEN ABATOR

FILTER SAMPLES

Retention Times	A 387 1 - 21	A 306* 1 - 19	A 351 1 - 20
1.68	70,154	1,241	408,666
2.08			442,304
2.18		4,040	
2.29	182,023		332,404
4.35	58,900	80,000	123,790
5.80	2,000		2,400
7.10	225		620
7.85	22		100
8.85			200
9.35			
9.60			

TABLE 3 continued . . .

FORKLIFT

FILTER SAMPLES

Retention Times	P 310 1 - 19	P 363 1 - 20	P 389* 1 - 21
1.68	107,421	55,326	734
2.08		77,511	
2.18			802
2.29	210,590	70,549	
4.35	74,000	55,274	40,000
5.80	2,580	1,030	
7.10	160	340	
7.85	105	156	
8.85	85	88	
9.35			
9.60			

TABLE 3 continued . . .

CAFETERIA

FILTER SAMPLES

Retention Times	A 369 1 - 20	A 376 1 - 21
1.68	98,914	169,516
2.08	112,774	
2.29	82,492	398,174
4.35	54,130	60,433
5.80	1,850	2,300
7.10	250	180
7.85	80	
8.85	160	
9.35		
9.60	160	

TABLE 3 continued . . .

L E A D E R (Belt Dept.)

F I L T E R S A M P L E S

Retention Times	P 302* 1 - 19	P 372 1 - 20
1.68	726	68,911
2.08		77,996
2.29		64,945
4.35	50,000	34,400
5.80		6,850
7.10		360
7.85		360
8.85		57
9.35		
9.60		

*50 µl injection volume

TABLE 3 continued . . .

2nd FLOOR OFFICE

FILTER SAMPLES

Retention Times	A 356 1 - 20
1.68	26,358
2.08	
2.29	56,228
4.35	55,420
5.80	2,260
7.10	175
7.85	
8.85	15
9.35	
9.60	

TABLE 3 continued . . .

MAINTENANCE

FILTER SAMPLES

Retention Times	P 318* 1 - 19
1.68	751
2.08	
2.18	724
2.29	
4.35	50,000
5.80	
7.10	
7.85	
8.85	
9.35	
9.60	

*50 µl injection volume

TABLE 3 continued . . .

C E I L I N G (beam #8)

F I L T E R S A M P L E S

Retention Times	A 317 1 - 19
1.68	28,551
2.08	20,635
2.29	
4.35	55,460
5.80	2,220
7.10	250
7.85	12
8.85	110
9.35	
9.60	

TABLE 3 continued . . .

HEAT SEAL PRESS (laminator)

FILTER SAMPLES

Retention Times	P 305* 1 - 19	P 371* 1 - 20	P 382* 1 - 21	A 313 1 - 19
1.68	644		522	157,712
2.08		608		175,333
2.17	1,347		502	
2.29				231,532
4.35	50,000	40,000	40,000	143,090
5.80	3,000			18,350
7.10				4,840
7.85				1,660
8.85				
9.35				
9.60				

*50 µl injection volume

TABLE 3 continued . . .

SWITCHBOARD

FILTER SAMPLES

Retention Times	A 362 1 - 20	A 354 1 - 21
1.68	292,054	119,155
2.08		103,766
2.29	689,076	108,085
4.35	64,414	78,530
5.80	2,760	2,130
7.10		130
7.85		
8.85	43	
9.35		
9.60		

TABLE 3 continued . . .

1st FLOOR EXEC. OFFICE

FILTER SAMPLES

Retention Times	A 370 1 - 20	A 332 1 - 21
1.68	42,299	28,351
2.08	62,843	14,673
2.29	73,180	
4.35	65,000	51,190
5.80	1,660	2,200
7.10	146	
7.85	407	
8.85	160	
9.35		
9.60	55	

TABLE 3 continued . . .

QUALITY CONTROL ROOM

FILTER SAMPLE

Retention Times	P 397 1 - 21
1.68	60,231
2.08	98,523
2.29	82,408
4.35	48,750
5.80	1,460
7.10	410
7.85	65
8.85	
9.35	
9.60	

TABLE 3 continued . . .

TOWER E

FILTER SAMPLES

Retention Times	P 316 1 - 19	P 364 1 - 20	P 388 1 - 21	A 343 1 - 21	A 322 1 - 19	A 358 1 - 20
1.68	137,880	47,611	83,118	30,137	38,562	70,896
2.08	125,667	76,024	119,430	16,296	39,176	
2.29	113,420	63,855	94,711	50,008		209,750
4.35	56,225	44,600	57,900	53,650	87,110	127,800
5.80	2,415	1,830	3,480	3,160	3,260	2,860
7.10	210		185	176		475
7.85	60	14				110
8.85						56
9.35				62		
9.60						

TABLE 3 continued . . .

TOWER B

FILTER SAMPLES

Retention Times	A 344 1 - 21	A 323 1 - 19	A 359 1 - 20
1.68	24,708	63,778	201,717
2.08	15,823	33,309	
2.29			457,043
4.35	34,030	45,370	133,000
5.80	1,380	4,150	2,600
7.10	165	270	330
7.85			
8.85		85	310
9.35	218	496	
9.60			53

TABLE 3 continued . . .

SLITTER

FILTER SAMPLES

Retention Times	P 312 1 - 19	P 374 1 - 20	P 365 1 - 20	P 386 1 - 21
1.68	4,521	60,736	132,659	118,958
2.08			234,859	264,838
2.29	2,107	143,260		
4.35	52,469	59,500	60,660	51,600
5.80	9,590	2,400	2,015	900
7.10	7,590	290	280	135
7.85	2,010	104	200	
8.85		180	206	
9.35				
9.60		31	42	

TABLE 3 continued . . .

GAS TOWER
FILTER SAMPLES

Retention Times	P 314 1 - 19	P 366 1 - 20	P 394 1 - 21
1.68	32,898	106,429	67,114
2.08		163,352	101,829
2.29	68,001	82,819	85,144
4.35	63,261	66,900	58,400
5.80	5,010	9,770	2,040
7.10	407	35	206
7.85	203	10	
8.85	118	244	
9.35			
9.60		92	

TABLE 3 continued . . .

TOWER G

FILTER SAMPLES

Retention Times	P 308 1 - 19	P 309* 1 - 19	P 373 1 - 20	P 368 1 - 20	P 349 1 - 21	P 391 1 - 21	A 321 1 - 19	A 336 1 - 21
1.68	59,599	744	147,441	142,856	23,069	114,651	58,793	63,758
2.08			198,878	263,876	16,381	156,670		42,190
2.29	110,937		140,444			123,339		
4.35	70,080	50,000	59,070	53,950	39,280	61,720	111,210	124,230
5.80	2,720		6,400	1,170	1,350	2,380	4,230	4,700
7.10	35		126	191	335	56	270	500
7.85			135	132	90	55	195	
8.85	110		136	96			160	
9.35				500	14			
9.60	40		60					

TABLE 4 - AREA AND JOB CATEGORY SAMPLES WITH HIGH CONCENTRATIONS AT MAJOR RETENTION TIMES

		RETENTION TIMES								
JOB/AREA	NO. SAMPLE	1.68	2.08	2.28	4.35	5.80	7.10	7.85	8.85	9.35
Slitter	6P	--	--	--	--	--	--	--	--	--
Gas Tower	3P	--	H	--	--	H	--	--	--	--
Tower E (old wide)	3P	H	H	H	--	--	--	--	--	--
	3A	--	--	--	H	--	--	--	--	--
Tower G (new wide)	6P	H	H	H	--	--	--	--	--	--
	2A	--	--	--	H	--	--	--	--	--
Tower B	3A	--	--	--	--	--	--	--	--	H
Calendar Operator	3P	H	H	H	--	--	--	--	--	--
Maintenance	1P	--	--	--	--	--	--	--	--	--
Laminator	2P	H	H	H	H	--	--	--	--	--
	2A	H	H	H	H	H	--	--	--	--
Cutter	3P	H	--	H	--	--	--	--	--	--
Leader Belt Dept.	2P	--	--	--	--	H	--	--	--	--
Heat Seal Press	3P*	--	IH	--	--	IH	--	--	--	--
	1A	H	H	H	H	H	H	H	--	--
Fork Lift	3P	--	--	--	--	--	--	--	--	--
Ceiling Bean 8	1A	--	--	--	--	--	--	--	--	--
QC Room	1P	--	H	H	--	--	--	--	--	--
1st Fl. Exec. Office	2A	--	--	--	--	--	--	--	--	--
2nd Floor Office	1A	--	--	--	--	--	--	--	--	--
Switchboard	2A	H	H	H	--	--	--	--	--	--
Cafeteria	2A	H	H	H	--	--	--	--	--	--
Electric Oven Abator	3A	H	H	H	H	--	--	--	H	--
Black Abater Residue					H					
CUT OFF FOR H		100,000	100,000	100,000	100,000	5,000	6,000	1,000	200	100

H = High

* = Analysis with 50 µl injection

IH = One sample value was high

the other samples.

During the walk-through inspection of the plant, three basic sources of exposure were identified: the towers in which the fabric was actually coated, the heat sealing operation in the belt department, and the laminating operation. Both the area and the personal samples taken in the laminating area contain relatively high levels of components with retention times of 1.68, 2.08, 2.28, and 4.35 minutes; the area samples also included one with a 5.80 minute retention time. The area sample from the heat seal press was high in all these compounds as well as in those eluting at 7.1 and 7.85 minutes. Two of the personal samples were low in all these compounds, but the third was high in the components with retention times of 2.08 and 5.80 minutes. These results are probably due to the employees not working adjacent to the heat seal press at all times.

Because smoke was emanating from Tower G and some people had reported that the health effects started after the new wide tower G began operation, a comparison of air levels near this tower with those from the old wide Tower E, was undertaken (Table 5). Generally, the measured levels of materials near Tower G were slightly but not significantly higher than those near Tower E. This may not accurately reflect the quantity of emissions because the samplers were not placed to measure the emission rates, but rather to measure area levels. Also, these electric tower emissions were not very different from those of the gas Towers A, B, C, and D.

The offices on the second floor had lower levels of exposure to the components studied. The cafeteria had higher levels of components with retention times of 1.68, 2.08, and 2.28, but other components were at lower levels.

B. MEDICAL

Of the 100 plant employees, 86 participated in the January survey. Five of the 86, however, refused to answer questions regarding sexual function. Of the

TABLE 5 - COMPARISON OF THE TOWER EMISSIONS

		RETENTION TIMES									
Tower	No. Samples	1.68	2.08	2.29	4.35	5.80	7.10	7.85	8.85	9.35	9.60
Gas (A-D) All personal	3	6.9	89	65	62,854	5,607	216	71	121	---	31
E Old Wide	6	70	59	85	71,214	2,834	174	51	10	10	0
G New Wide	7		97	54	74,220	3,280	216	87	72	3	125
B (Gas all area)	3	96	16	152	70,800	2,710	255	--	132	238	18
E-personal		90	108	91	53,000	2,600	130	25	--	--	---
E-area		50	11	78	90,000	3,100	220	37	19	21	---
G-personal		92	127	75	57,000	2,800	150	82	68	28	120
G-area		61	21	--	118,000	2,200	385	98	80	--	---

remaining 14 non-participants, 11 were women either away on vacation or declining participation. Thus, 81 percent of the total employees and 96 percent of the male employees were surveyed in January 1981. The January survey included complete health, smoking and work questionnaires, a physical exam with attention to the genito-urinary and neurologic systems, and blood assays of testosterone and prolactin as well as complete blood counts and chemical screen were completed on all 86 participants.

A follow-up survey was performed in April, 1981. Complete questionnaires were obtained on 28 male employees; ten of these were employees who had been identified as having erectile dysfunction during the January survey, and 18 were a stratified sample of the remainder of the work force similar to each other in age and type of employment at the plant.

1. Erectile Dysfunction.

Ten of the 64 males surveyed in January responded positively to questions regarding sexual dysfunction within the preceding 36 months. Three of these males had returned to normal function at the time of the January survey. Two others had normalized between January and April. Therefore, as of April, five men met our case definition of persistent erectile dysfunction, and five others were classified as transient erectile dysfunction that had resolved at the time of the resurvey. Two of the persistent cases revealed that the onset of erectile dysfunction preceded their employment at Chemical Fabrics.

The onset and duration of persistent and transient erectile dysfunction among employees is displayed in Tables 6 and 7. As displayed, four of the five transient cases, and one of the three persistent cases associated with employment had onset within six months of the January survey.

Cases of persistent erectile dysfunction have been reviewed in detail (Table 8). All of the cases except case #3 had normal physical exams and chemical

TABLE 6: TIME OF ONSET AND DURATION OF TRANSIENT AND PERSISTENT ERECTILE DYSFUNCTION

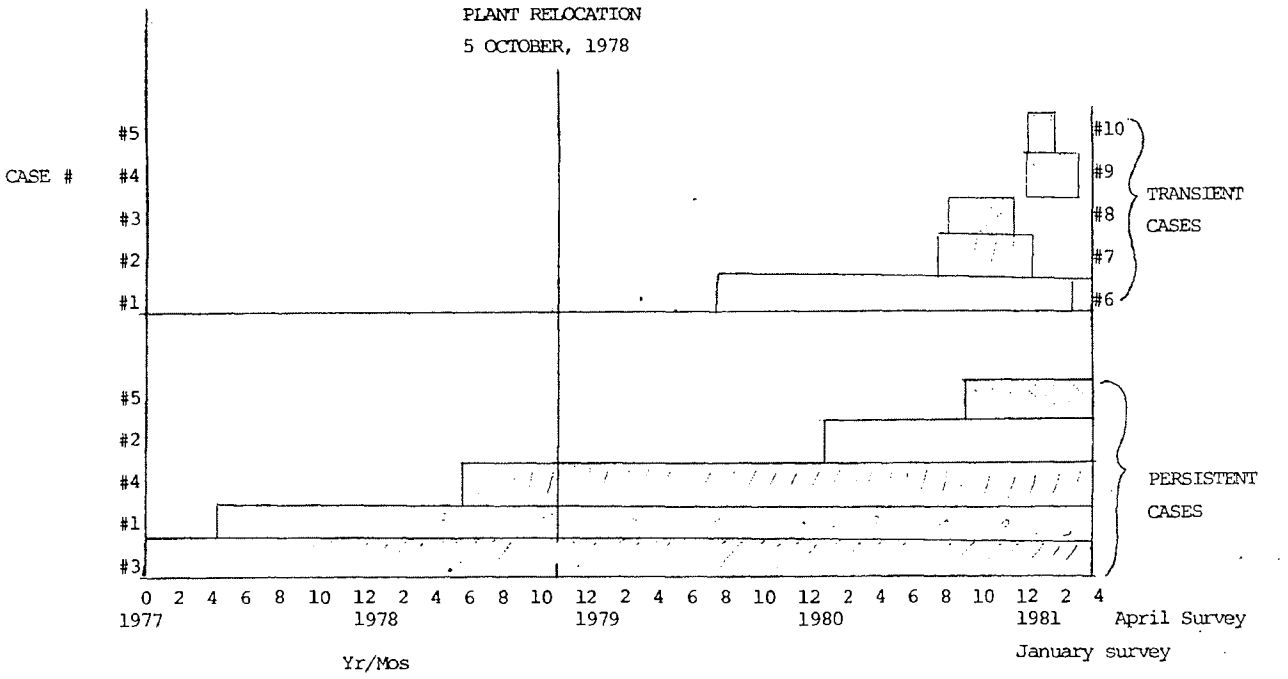


TABLE 7: INCIDENCE OF ERECTILE DYSFUNCTION

DATE OF ONSET

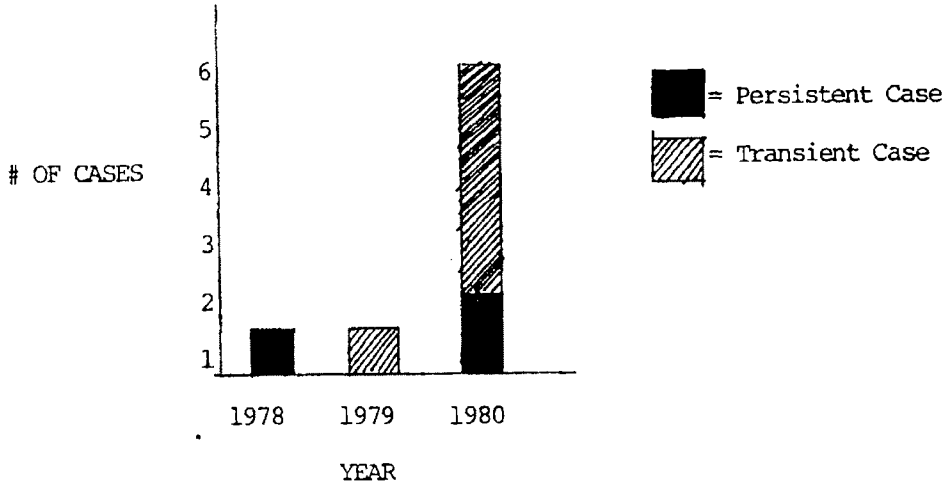


TABLE 8: PERSISTENT ERECTILE DYSFUNCTION: SUMMARY OF CASES

Case #	Age Group	Duration Employed	Work Area	Onset of E.P.	PFF Classical # Episodes	PFF Partial # Episodes	Current Smoker	Physical Exam	Lab	Comments
1	40-49	>1 yr	Production	3/77	0	0	No	Normal	nl	Onset prior to employment at ChemFab
2	50	>10 yr	Production	1/80	0	Many	Yes	Normal	Normal	
3	50	>1 yr	Non-Prod.	1977	0	0	No	Atrophic Testes	Elevated Prolactin	Onset prior to employment at ChemFab
4	50	> 5 yr	Production	5/78	3	7	Yes	Normal	nl	On antihypertensive medication
5	30-39	>2 yr	Production	9/80	5	100	Yes	Normal	Elevated RBC count nl hormones	

tests; case #3 had atrophic testes and a mildly elevated prolactin level and had undergone evaluation for impotence prior to his employment at Chemical Fabrics. Likewise, case #1 had noted onset of sexual problems prior to employment at Chemical Fabrics. Of the cases with onset since employment at Chemical Fabrics (cases #2,#4, and #5), two worked in the belting department, and one worked in maintenance. No obvious cause of erectile dysfunction unrelated to their employment was discovered in the physical exams, blood studies of these cases or psychological profiles.

Cases of transient erectile dysfunction were also reviewed (Table 9). All cases of transient erectile dysfunction reported normalization of function as of the April survey. All had normal physical exams and blood tests except case #6 who had an elevated blood glucose. All abnormal test results have been communicated directly to the employees involved, and to their physicians if so indicated by the employee.

Exposures measured on the days surveyed were not correlated with the occurrence of erectile dysfunction. The three cases of persistent erectile dysfunction (from the maintenance and beltmaking departments) worked in areas with relatively low general exposures on the days surveyed (Table 4).

Since the available data suggests that the prevalence of erectile dysfunction increases with age, we stratified by age and prevalence of erectile dysfunction on the study population (Table 10). This table demonstrates that the overall prevalence of persistent erectile dysfunction (including those with "pre-exposure" erectile dysfunction) was 7.8 percent. When the "pre-exposure" cases of erectile dysfunction are excluded the prevalence drops to 4.8 percent.

In order to further explore a possible relationship between erectile dysfunction and plant exposures, we divided the cohort into "production area" jobs and "non-production area jobs" based on the approximate number of hours spent on

TABLE 9: TRANSIENT ERECTILE DYSFUNCTION: SUMMARY OF CASES

Case #	Age Group	Duration Employed	Work Area	Onset of E.P.	PFF Classical # Episodes	PFF Partial # Episodes	Current Smoker	Physical Exam	Lab	Comments
6	40-44	> 10 yr	Production	7/79 → 4/81	0	2	Yes	Nl	Nl	
7	< 30	2 yr	Non-Prod.	7/80 → 12/80	0	0	No	Nl	Nl	
8	< 30	> 1 yr	Production	8/80 → 11/80	2	75	Yes	Nl	Nl	
9	30-40	< 1 yr	Non-Prod.	1/81 → 3/81	0	0	No	Nl	Nl	
10	< 30	2 yr	Production	12/80 → 1/81	2	1	No*	Nl	Nl	* Had been smoking at time of PFF episodes

TABLE 10: PREVALENCE OF PERSISTENT ERECTILE DYSFUNCTION

(APRIL SURVEY) BY AGE

Age	All Employees	(Excluding pre-existing E.D.) All Employees	(Minus exclusions) Production Area	Production Area (Previous E.D. included)	Non-Prod. Area (Previous E.D. included)
30	0/25 (0%)	0/25 (0%)	0/19 (0%)	0/19 (0%)	0/6
30-39	1/20 (5%)	1/20 (5%)	1/8 (12.5%)	1/8 (12.5%)	0/12
40-49	1/10 (10%)	0/9 (0%)	0/5 (0%)	1/6 (16.6%)	0/3
50	3/9 (33%)	2/8 (25%)	2/5 (40%)	2/5 (40%)	1/4 (25%)
Total	5/64 (7.8%)	3/62 (4.8%)	3/37 (8.1%)	4/38 (10.5%)	1/26 (3.8%)

the general shop floor per week (Table 11). The overall prevalence for the production area was 10.5%, including pre-exposure cases (one from the production area, one from the non- production area), and was 3.8% for the non-production area.

Age stratification revealed that in only one of the cases of persistent erectile dysfunction that had occurred since employment was the worker under 50 years of age. The age specific prevalence rates are reported in Table 10.

Female participants in this survey, which included two production area workers and 15 office workers, all gave negative histories for bladder or sexual dysfunction, peripheral neuropathy, or polymer fume fever symptoms.

2. Polymer Fume Fever

Detailed respiratory, smoking, and polymer fume fever histories were obtained on the 28 males in the April survey because of concern about polymer fume fever symptoms revealed during the January survey. As mentioned, polymer fume fever (PFF) was defined as shaking chills, myalgias, shortness of breath, chest tightness, and malaise with or without a measured increase in body temperature, which occurred near the end or soon after the end of a workshift, and had complete resolution of the symptoms within 24 hours (18). This syndrome is reported only in workers that are exposed to the pyrolysis products of fluorocarbon polymers, but is otherwise similar in presentation to metal fume fever (19).

Six of the 28 male employees in the April survey had experienced between one and ten episodes of classical PFF since the plant's relocation in 1978. Smokers in the production area (27.8 percent) are the most likely to get symptoms of PFF (Table 12). No non-smokers, and only one smoker from the non-production area gave histories of classical PFF.

TABLE 11: JOB DISTRIBUTION BY EXPOUSRE AREA - JANUARY COHORT

(N.B.: Cohort includes 2 pre-existing cases of Erectile Dysfunction)

Production Area Jobs (20 hours/week on general shop floor)

Job Title	Number of Employees
Tower Operators	19
Maintenance	5
Rerollar	2
Supervisors	5
Beltmakers	4
Calendar Operaator	1
Laminator	1
Total	38

Non-Production Area Jobs (20 hours/week on shop floor - generally spend 50% of time in enclosed area separate from shop floor)

Job Title	Number of Employees
Executive	6
R&D	6
Managers	4
Laboratory	3
Machine Shop	2
Clerical	1
Staff Engineer	1
Formulator	1
Draftsperson	1
Custodian	1
Total	26

Total Cohort 26 + 38 = 64 males

TABLE 12: POLYMER FUME FEVER - CLASSICAL AND PARTIAL

FREQUENCY BY PRODUCTION AREA, STRATIFIED BY SMOKING

	Frequency of Classical PFF (1 or more episodes)	Frequency of Partial PFF
Non-Production Area	1/10 (10%)	0/10 (0%)
Smokers	1/3 (33%)	0/3 (0%)
Non-Smokers	0/7 (0%)	0/7 (0%)
Production Area	5/18 (27.8%)	14/18 (77.8%)
Smokers	4/8 (50%)	7/8 (87.5%)
Non-Smokers	1/10 (10%)	7/10 (70%)
All Areas (April survey)	6/28 (21.4%)	14/28 (50%)
All Smokers	5/11 (45.4%)	7/11 (63.6%)
All Non-Smokers	1/17 (5.9%)	7/17 (41.2%)

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APPENDIX A

Sample Type	Collection Medium	Manufacturer
Respirable Mass	Mixed cellulose ester filters .8μ pore size 37 mm. diameter	Millipore Corporation Bedford, MA
Total particulate	Mixed cellulose ester filters .8μ pore size 37 mm. diameter	Millipore Corporation Bedford, MA
Total particulate (high-volume)	Glass fibre filters 8" x 10" sheet	Mine Safety Appliances Co. Pittsburgh, PA
Organic vapors	Small charcoal tubes	A.J. Sipin Compnay NY, New York
Organic vapors	Small silical gel tubes	SKC, Incorporated Eighty Four, PA
Total particulate	Mixed cellulose ester filters in line with large charcol tubes	Millipore Corporation A.J. Sipin Company

APPENDIX B

HEALTH HISTORY QUESTIONNAIRE

NAME _____ ADDRESS _____

AGE _____ BIRTHDATE ___/___/___ (mo. day yr.) _____

DATE _____ TELEPHONE _____

SOCIAL SECURITY NUMBER _____

CURRENT JOB TITLE _____

_____

_____

WHEN DID YOU START WORKING FOR THIS COMPANY? ___/___ (mo. yr.) IN YOUR CURRENT JOB ___/___ (mo. yr.)

What substances do you work with? _____

_____

Please list all prior jobs you have had within this plant since you first started work(most recent job first).

Job	Dates	Hazards (Noise, fumes, ect.)
1.		
2.		
3.		
4.		

Please list prior jobs, since high school (most recent job first)

Employer	Dates	Hazards (Noise, fumes, ect.)
1.		
2.		
3.		
4.		

(Continue on other, if necessary)

GENERAL HISTORY

Do you have a history of:	yes	no
Diabetes		
Family member with Diabetes		
Heart Disease		
Hypertension		
Gonorrhea		
Syphilis		
Thyroid Disease		
Hives or Rashes		
Eczema		
Bronchitis		
Pneumonia		
Emphysema		
Any Glandular Disease		
Liver Disease		
Neuralgia or Neuritis		
Pancreatitis		
Kidney Trouble		
Yellow Janudice		
Sickle Cell		
Other		

General History (Continued)

1. Do you get headaches? Yes No

   If yes, how often? _____ _____

2. How many hours a night do you sleep?_____

   Have you ever had to sleep more than that after your usual day of work? Yes No

   If yes, how much more? _____ _____

   Why? _____

3. Have you had a fever measured by yourself or your doctor in the past three years? Yes No

   If yes, how many times and how high was each?_____

ALCOHOL HISTORY

1. How often do you drink?

   _____a. 2-3 times/day
   _____b. 4-7 times/week
   _____c. 1-3 times/week
   _____d. 1+/month
   _____e. less than once/month
   _____f. never
   _____g. don't know

2. When you drink, how many drinks do you usually have?_____

3. How often do you drink 5 or more drinks?

   _____a. 4+/week
   _____b. 1-3/week
   _____c. 1+/month
   _____d. less htan once/month
   _____e. never
   _____f. don't know

DIABETES HISTORY

Do you have:	Yes	No
Excessive thirst		
Change of Appetite		
Frequent Urination (greater than 5-6 times/day)		
Night-time urination		
Weight change		

VASCULAR DISEASE HISTORY

Have you ever been told that you have poor circulation to your legs by a doctor?_____

Have you ever been told that you have atherosclerosis?_____

When walking, do you get pain in your calves so that you have to stop and rest?_____. At what distance does this happen?_____.

GENITO-UROLOGIC HISTORY

Do you have:	Yes	No
Difficulty initiating urination?		
Need to strain?		
Decrease in size of urine stream?		
Feeling that the bladder is still full after voiding?		
Constantly feeling the need to urinate?		
Need to take longer than usual to urinate?		
Wetting of the pants or bed?		
Burning on urination?		
Sores on the penis and/or testicles?		

Genito-Urologic History (Continued)	Yes	No
Swelling of the penis and/or testicles?		
Pain on erection and/or ejaculation?		
Discharge from the penis?		

Were you born with any abnormalities of your penis and/or testicles?____

NEUROLOGIC HISTORY

Do you have:	Yes	No
Numbness and/or tingling in the arms?		
Numbness and/or tingling in the legs?		
Decreased sensation in the legs?		
Low back pain?		

SEXUAL HISTORY

How would you describe your degree of sexual desire?

Strong

Moderate

Mild

None

How many times do you have sexual intercourse or masturbation per week?

_____

Does your penis get firm with masturbation?_____

How many early morning erections do you have per week?_____

Do you have swelling of the breasts and/or discharge from the nipple?____

_____

Do you have a tendancy to be irritable and fight with family/friends?____

Sexual History (Continued)

How many children do you have?_____

What are their dates of birth?_____

_____

Were any of your children born with a disability or birth defect? Yes No

If yes, please describe_____

In spouses:

No of abortions: spontaneous_____

induced_____

No. of stillbirths_____

For Women:

At what age did you start menstruation?_____

Have you stopped menstruating? _____ If yes, at what age did you stop? _____

How many times have you been pregnant? _____

How many children do you have? _____

If you mensttuate, are your periods regular? _____

If no, when did they start to become irregular? _____

Have you had any abortions? _____ If yes, how many? _____

DRUG USE HISTORY

Are you currently taking any medication?_____

Any blood pressure drugs, tranquilizers, sedatives, sleeping medications or hormones?_____

If so, when did you start?_____

Dose, frequency_____

Do you take any drugs that are not prescirbed by a doctor, such as Marijuana, Cocaine, Uppers or Downers?_____

If so, when did you start?_____

Dose, frequency_____

APPENDIX C

Bennington Follow-up
Questionnaire

1. Name_____ Date_____

2. Exposure

	DATE	JOB	TIME ON FLOOR (hrs/wk)	TOPSIDE(hrs/wk)	SMOKE-FILLED ROOM OR OTHER EVENTS NEEDING VENTILATION (no/mo.)	SMOKE-FILLED ROOM OR OTHER EVENTS NECESSITATING LEAVING (no./mo.)	"TEFLON" FUME FEVER (CLASSIC) (no. of times)	"TEFLON" FUME FEVER(PARTIAL) (no. of times)
Before 1978								
At Time of Move(Oct 1978)								
After Oct 1978								
Job 1 from mo / yr								
to mo / yr								
Job 2 from mo / yr								
to mo / yr								
Job 3 from mo / yr								
to mo / yr								

DATE	JOB	TIME ON FLOOR (hrs./wk)	TOPSIDE(hrs./wk)	SMOKE-FILLED ROOM OR OTHER EVENTS NEEDING VENTILATION (no/mo)	SMOKE-FILLED ROOM OR OTHER EVENTS NECESSITATING LEAVING (no/mo)	"TEFLON" FUME FEVER (CLASSIC) (no of times)	"TEFLON" FUME FEVER (PARTIAL) (no of times)
Job 4 from mo/yr							
to mo/yr							
Job 5 from mo/yr							
to mo/yr							

3. Description: Details of above - smoke filled episodes, or Polymer Fume Fever. What were you doing? For how long? With Polymer Fume Fever, what were the first symptoms? When did they occur? How long did they last?

_____

_____

_____

_____

4. Sexual History

A. Libido: Sexual drive is now:

1. Strong
2. Moderate
3. Mild
4. None

Has this been constant, at the same level, for past three years? _____. If no, when did change occur?_____ month/year

B. How many times do you have sexual intercourse or masturbation per week?_____

Has this been constant, at the same level, for the past three years?_____ If no, when did change occur?_____ month/yr

Has the pattern changed because of absence or change of a partner? _____

_____

_____

C. Except on a rare occasion, have you had trouble getting an erection? Yes No

If yes, are you currently experiencing difficulty in getting an erection ? Yes No

How long did it last?_____ months

Can you recall if this was, in any way, related to work?

Yes No

If yes, please explain_____

_____

_____

_____

D. Does you penis get firm on masturbation? Yes No

If no, is this a change? Yes No

If yes to above, when did change occur? _____
month / year

E. How many times per week do you awaken with an erection?

_____
number of times

How often are these full erections? _____
number

F. Do you experience ejaculations? Yes No

If no, is this a change? Yes No

If yes to above, when did the change occur? _____
month/year

5. Alcohol History

A. How often do you drink?

_____a. 2-3 times/day

_____b. 4-7 times/week

_____c. 1-3 times/week

_____d. 1+/month

_____e. less than once/month

_____f. never

_____g. don't know

B. When you drink, how many drinks do you usally have? _____
number

C. How often do you drink 5 or more drinks?

_____a. 4+/week

_____b. 1-3 times/week

_____c. 1+/week

_____d. less than once/month

_____e. never

_____f. don't know

6. Drug Use History

A. Are you currently taking any medication?_____

B. Any blood pressure drugs, tranquilizers, sedatives, sleeping medications or hormones?_____

If so, when did you start?_____

Dose, frequency_____

C. Do you take any drugs that are not prescribed by a doctor, such as Marijuana, Cocaine, Uppers or Downers?_____

If so, when did you start?_____

Dose, frequency_____